

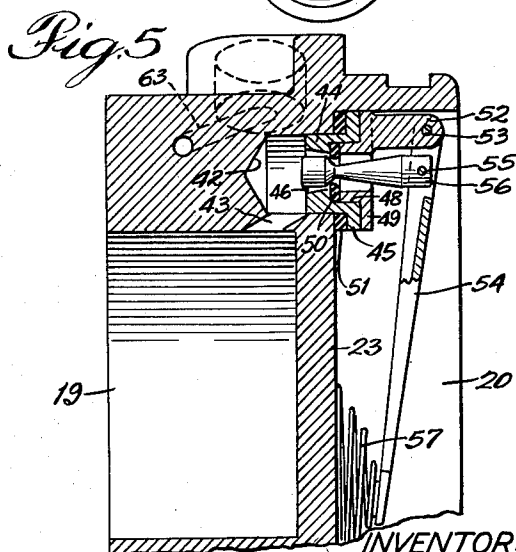
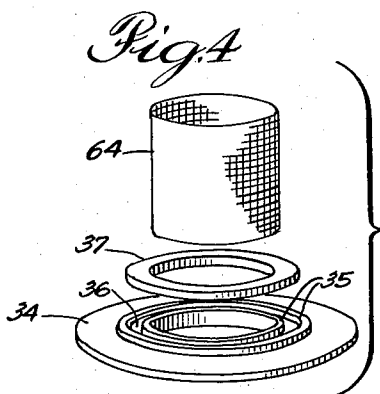
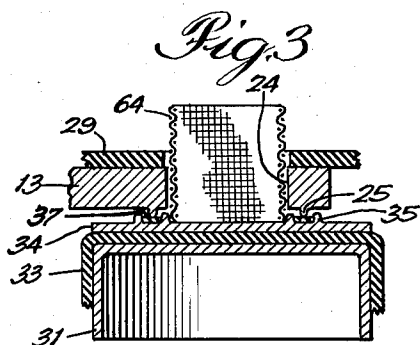
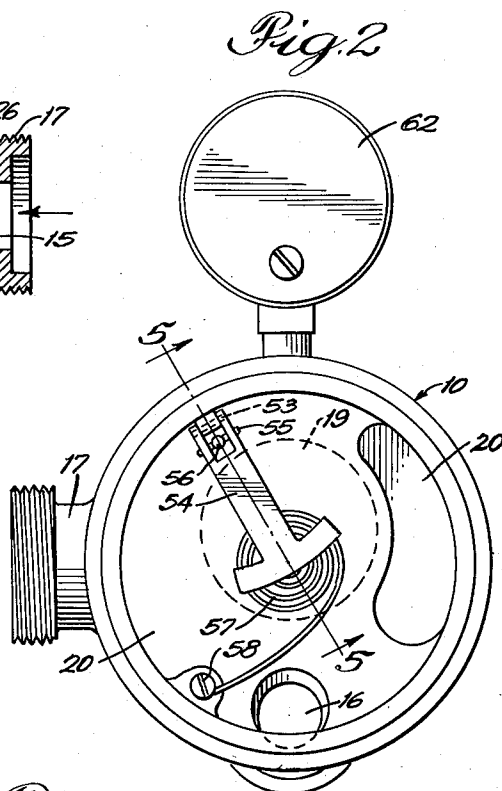
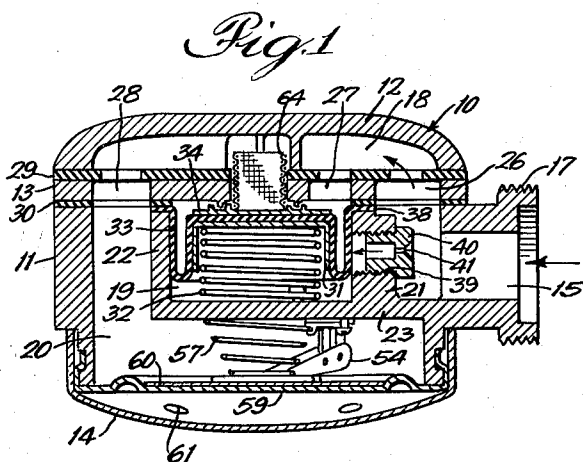
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DAMPING MEANS FOR MODULATING VALVE

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DAMPING MEANS FOR MODULATING VALVE

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This invention relates to damping means for a modulating valve and more specifically to means for guiding and controlling the action of a primary valve member in a device for modulating the flow of compressed air to a gas mask.

The present application is a continuation-in-part of my copending application Serial No. 552,573, filed December 12, 1955, and now abandoned.

The aforementioned copending application discloses an extremely sensitive valve assembly for modulating the flow of compressed air to a gas mask so that the variations in air flow closely correspond with the varying air requirements and the breathing patterns of a person wearing the mask. This is accomplished by providing a unit having a primary chamber in direct communication with a source of compressed air and a secondary chamber also in communication with the source through a restricted bleed port. In addition, the primary chamber is provided with a high capacity flow passage and the secondary chamber is provided with a flow capacity passage (of larger size than the bleed port), both passages being adapted to communicate with a gas mask and being normally closed by primary and secondary valve elements. However, the secondary passage is easily opened in response to a demand for air by the action of a diaphragm and connecting lever means. Since the air streaming from the secondary chamber through the secondary flow passage is inadequate to meet the demand for air by the gas mask wearer, the pressure differential between the primary and secondary chambers immediately results in the opening of the primary flow passage to the extent necessary to meet the air requirements of the gas mask wearer.

Applicant has found that the operating characteristics of the valve assembly described above tend to vary somewhat over a wide range of source pressures and that under certain operating conditions the main valve will tend to "hunt"; that is, to shift between extreme positions until it finally settles at the most suitable open position to meet the air requirements of a wearer. Specifically, it has been found that valve hunting will occur to a greater extent if the source pressure is relatively low, or where the main valve port is of relatively large diameter, or where the force actuating the main valve member is relatively slight. Conversely, hunting occurs to a lesser extent, if at all, when the source pressure is high, where the main port is relatively small, or where the valve actuating force is comparatively strong. The problem lies in the fact that a highly effective gas mask demand valve should be capable of operating over a wide range of pressures, including source pressures of 15 pounds per square inch (p.s.i.) or even lower. Also, since the valve unit must be highly responsive to the wearer's demands, the main valve passage should be of relatively large diameter and the force necessary to actuate the primary valve member should be relatively slight. Thus, the same factors which are necessary for a sensitive and highly responsive

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demand valve also tend to increase the "hunting" tendency of the primary valve member under low pressure conditions.

A principal object of the present invention is to provide a control valve equipped with means for insuring smooth operation of a main valve member over a wide range of gas pressures. Specifically, it is an object to provide damping means for insuring smooth valve operation under source pressures ranging between 2 to 150 p.s.i. or more. Another object is to provide means for damping axial movement of the primary valve elements so that when the pressure in the secondary chamber is reduced below the pressure in the primary chamber the primary valve element will move immediately into the precise open position required to meet the air demand without "hunting" and thereby passing more or less air than is actually required. Another object is to provide means which not only dampens but which also cooperates with other elements of the valve combination, to guide the movement of a valve member in a modulating valve assembly and to prevent excessive or erratic movement of that member as it moves between closed and open positions. Other objects will appear from the specification and drawings in which:

Figure 1 is a horizontal sectional view of a modulating valve assembly including the valve damping means of the present invention; Figure 2 is a rear elevational view of the valve assembly with the rear cover of the diaphragm removed therefrom to expose the linkage for the secondary valve element; Figure 3 is an enlarged broken horizontal section of the valve assembly showing the primary valve element and the damping means therefor; Figure 4 is an enlarged perspective view illustrating the primary valve element and damping means in exploded condition; and Figure 5 is an enlarged sectional view taken along line 5—5 of Figure 2.

In the structure shown in the drawings, the control valve casing indicated generally by the numeral 10 consists essentially of a casing body 11, a detachable front wall or cover 12, a perforate valve plate 13, and a perforate rear wall or cover 14. The component parts of the valve casing are preferably formed from a sturdy, lightweight material such as aluminum or other relatively light metal.

The casing body is provided with an inlet 15 and an outlet 16. As shown in Figures 1 and 2, an outwardly extending neck portion 17 is formed integrally with the casing body and is threaded to receive a hose connection so that inlet 15 may be placed in communication with a source of compressed air (not shown). If desired, a primary pressure regulator for reducing the pressure of air escaping from the air supply source may be interposed in the line between the source and the control or modulating valve, as is well understood in the art. Outlet 16 may be placed in communication with a suitable gas mask (not shown), the valve assembly thus being disposed between a compressed air source and a mask. The air source may be the usual compressed air tank or any chamber or conduit which receives compressed air from suitable compressor means. Since such structures are well-known in the art and since the gas masks which may be used in connection with the present invention are entirely conventional it is believed that a detailed description of such apparatus is unnecessary herein.

From Figure 1 it will be seen that the valve casing provides a primary or inlet chamber 18 communicating with inlet 15, a secondary or intermediate chamber 19 and an outlet chamber 20. The intermediate or secondary chamber is generally cylindrical in shape and is defined in part by side partitions 21 and 22 and by rear partition 23 which are formed integrally with the casing body 11.

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As best shown in Figures 1 and 3 the valve plate 13 is equipped with a central aperture 24 which will be referred to as the primary port. An annular lip 25 extends about this port on the inner side of valve plate 13 to provide a valve seat for the port. In addition, the valve plate is provided with openings 26, 27 and 28 which, in combination with flow port 24, define a continuous primary flow passage from inlet 15 to the outlet chamber 20. As shown in Figure 1, the valve plate may be sandwiched between a pair of apertured gaskets 29 and 30 which insure an airtight assembly of the casing body, valve plate and front cover without obstructing the primary flow passage. The gaskets may be formed of rubber or other resilient and non-porous materials.

Within the intermediate or secondary chamber 19 is a generally cup-shaped member 31 oriented so that its base is directed forwardly towards the primary port of the valve plate. In the illustration given, a helical compression spring 32 extends between rear partition 23 and the base of the cup-shaped member and urges that member towards the primary port, although it will be understood that other means might be used for biasing the member 31 upwardly. A thin flexible diaphragm 33 serves both as a flexible wall for the intermediate chamber 19 and also has pressure-responsive means for operating the primary valve member or element 34. In Figures 3 and 4 it will be seen that valve member 34 comprises a plate or disk having a pair of spaced concentric ridges 35 defining a channel 36 therebetween. Within this channel is a sealing ring 37 formed of rubber or other resilient material, the ring being adapted to seat against the annular lip 25 of the valve plate when the primary valve is closed, as shown in Figures 1 and 3.

The flexible diaphragm 33 lines the outer surface of the cup member's base, then extends rearwardly along the cylindrical side wall of that member, and finally turns forwardly upon itself and extends along the cylindrical wall of the intermediate chamber 19. The peripheral edge 38 of the diaphragm is securely clamped between the front surface of the casing body 11 and the rear surface of gasket 30 so that the intermediate chamber 19 is sealed from communication with the primary flow passage defined above.

Through the side partition 21 and extending between inlet chamber 18 and intermediate chamber 19 is a threaded bore 39 which threadedly receives a fitting 40. A bleed port 41 through fitting 40 places the inlet chamber and the intermediate or secondary chamber in communication.

In the casing body wall above and near the rear of the intermediate chamber 19 is a forwardly extending bore 42 (Figure 5). A passage 43 extends from the intermediate chamber 19 into the front portion of bore 42 and, in combination with that bore, provides a secondary passage for the flow of air from the intermediate chamber into the outlet chamber 20. Within bore 42 is a secondary valve fitting 44 having an outwardly turned rear flange 45 and having an inner bore 46 therethrough. As shown in Figure 5, the inner bore 46 is provided with a rearwardly tapered forward portion and with a rear portion which snugly receives the sleeve 48 of lever support member 49. An annular secondary valve seat 50, preferably composed of a resilient material such as rubber, is clamped within the inner bore 46 by sleeve 48. A ring washer 51 of a resilient nonporous material such as rubber may be interposed between the casing body and the flange 45 of fitting 44 to insure an airtight connection between these parts.

Lever support member 49 is equipped with a rearwardly extending arm 52 having a pin 53 which pivotally supports lever 54. As represented most clearly in Figure 2, the outer end of lever 54 provides a pair of legs which straddle arm 52 and are apertured to receive pin 53. A second pin 55 is carried by the legs of lever 54 adjacent and parallel to pin 53 and behind the inner bore 46 of

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fitting 44. A secondary valve member 56 is apertured at one end to pivotally receive pin 55 and projects forwardly through the inner bore 46. In Figure 5 it will be seen that the forward end of the elongated valve member has an enlarged head with a frusto-conical rear portion adapted to seat against the annular secondary valve seat 50 when lever 54 is pivoted rearwardly.

The enlarged free end of lever 54 is biased rearwardly by a light compression spring 57 disposed between the rear partition of the casing body and the lever. Any suitable means may be provided for securing the spring to the casing body such as, for example, screw 58.

The pivotally mounted lever 54 is actuated by a diaphragm 59 which extends over the entire rear portion of the casing body as shown in Figure 1. The diaphragm is preferably formed from a flexible, non-porous material such as rubber and may, if desired, carry an inner liner 60 composed of a relatively stiff material such as paper or suitable plastic for contacting the pivotal lever 54. It will be noted that the rear cover 14 is provided with perforations 61 so that the flexible diaphragm 59 is exposed to atmospheric pressure on one side and the pressure of compressed air in the primary outlet chamber 20 on its other side.

In the structure illustrated in the drawings I have shown the valve casing equipped exteriorly with a pressure gauge 62 which communicates through passage 63 with the inlet chamber 15. Since the structure and operation of this gauge has been fully described in my copending application Serial No. 552,573, and since it forms no part of the present invention, further description of this structure is believed unnecessary herein.

Referring again the primary flow port 24 and primary valve member 35 shown in Figures 1, 3 and 4, it will be noted that a cylindrical screen or porous element 64 extends forwardly through the port and is welded or otherwise secured at its rear end to member 34. As indicated in Figure 3, the diameter of the primary port is sufficiently larger than the outer diameter of the sleeve to provide a narrow annular space therebetween. The porous sleeve is therefore freely movable through the port as the valve member shifts between open and closed positions, and it will be observed that the length of the sleeve is substantially greater than the width of the valve plate 13. Thus, even when the primary valve member is in its fully opened position at least some portion of the sleeve's forward end will be disposed within the primary port 24. Preferably, the sleeve or cylinder 64 is formed from fine wire mesh although it will be understood that other porous materials may be used.

The primary valve member 34 may be secured to diaphragm 33 by a suitable adhesive or by any other appropriate means. Similarly, the diaphragm may be adhesively secured to the base portion of the cup-shaped member 31.

In the operation of the device illustrated in the drawings, compressed air passing through inlet 15 flows into the primary chamber of the valve casing as indicated by the arrows shown in Figure 1. When the primary valve element 34 is in the seated position shown, compressed air cannot flow forwardly through the primary valve port 24 and into the outlet chamber 20. Thus, the primary high capacity flow passage including chambers 18 and 20 and primary port 24 is closed. Air streaming through bleed port 41 into the secondary chamber 19 equalizes the pressure in the secondary and primary chambers and under these conditions the means biasing the primary valve element is able to maintain that element in seated position.

Air within the secondary chamber will be maintained at the same pressure as air within the primary chamber and the primary valve member will remain in closed position as long as the secondary valve member 56 sealingly engages the annular secondary valve seat 50. However, when lever 54 is pivoted forwardly, the secondary valve

member is unseated and air escapes from the intermediate chamber through the passage 46 and into the outlet chamber 20. Since the secondary flow passage is considerably larger than the bleed port 41, compressed air will generally escape from the secondary chamber 19 at a faster rate than it can enter that chamber through the bleed port. The rate at which air is allowed to escape through the secondary flow passage 46 is of course dependent upon the distance that the frusto-conical valve member is moved forwardly within the passage and away from the secondary valve seat. If the secondary valve is fully opened, the air pressure in chamber 19 will drop quickly because of the rapid flow of air through the secondary valve passage and into the outlet chamber. The high pressure air in front of the pressure responsive diaphragm 33 will drive the primary valve member into an unseated position because of the pressure differential across that diaphragm. When the primary valve member is unseated, air may flow from the inlet 15 to the outlet 16 through the primary flow passage. If the secondary valve member is only partially unseated then diaphragm 31 and the primary valve member 34 will respond more slowly; and if the secondary valve member is moved so slightly that the annular space between the frusto-conical head and the tapered inner wall of fitting 44 is the same as the cross-sectional area of the bleed port 41 then the primary valve member will remain seated.

As shown in Figures 1 and 5, the secondary valve member is carried by the pivotally mounted lever 54 which is actuated by diaphragm 59. When there is no pressure differential across diaphragm 59 or when the pressure upon the inner or front surface of that diaphragm is greater than the pressure upon the diaphragm's outer or rear surface, spring 57 will be effective to bias the secondary valve member into seated position. In other words, when the air pressure within the outlet chamber 20 is the same or greater than the atmospheric pressure about valve casing 10 the secondary flow passage will remain closed. Since the secondary valve member is carried by the lever 54 adjacent the outer pivotal mounting of that lever and at a relatively substantial distance from the lever's inner end, the mechanical advantage in the operation of the lever and the secondary valve member is substantial. It has been found that a negative pressure in the outlet chamber of approximately 0.4 inch of water is sufficient to draw diaphragm 59 forwardly, thereby actuating the secondary and primary valves. Therefore, it is believed apparent that the present valve structure may be operated easily and effortlessly by a gas mask wearer.

Since the operation of the primary valve is governed or triggered by the action of the secondary valve, the present structure closely corresponds in operation with the various breathing patterns of a user. For example, during normal respiration, the amount of air inhaled varies during each inspiration period and reaches a maximum at about the middle of each period. As the degree of negative pressure varies, lever 54 within the outlet chamber 20 adjusts its position and thereby directly controls the flow of air through the secondary flow passage and indirectly regulates the flow through the primary flow passage. Consequently, the demand valve of the present invention regulates the flow of air according to the needs of the gas mask wearer and does not discharge wasteful or excessive amounts of air into the mask.

During periods of activity or exertion, or during periods of normal speech, it is well-known that large amounts of air are required and that the duration of the inspiration periods is relatively short. The control valve is particularly well adapted for quickly supplying the large amounts of air needed under these condition. As the gas mask wearer inhales sharply the air is immediately evacuated from the outlet and secondary chambers and the primary valve snaps open to provide a direct flow of air through the primary flow passage and into the gas mask.

The damping means 64 of the present invention is particularly important in the operation of the valve as-

sembly because it prevents the primary valve element from "hunting" its proper position when pressure within the secondary chamber drops. In other words, the porous sleeve 64 eliminates or greatly reduces the possibility that under certain conditions the primary valve element might momentarily overshoot or undershoot its proper position as it snaps open in response to a pressure drop in the secondary chamber.

Since the difference in diameters of the sleeve 64 and the primary port 24 is great enough so that a narrow annular space is provided therebetween, and since the screen can in fact move longitudinally through the port without engaging the walls thereof, it is evident that the elimination of "hunting" results primarily or largely from some factor other than the frictional resistance between the parts. The port may of course slidably engage the sides of the sleeve to guide axial movement of that sleeve and the primary valve, but this "snubbing" or guiding effect differs from the damping of "hunting," the latter resulting principally from a different function of the parts.

While the precise theory of operation responsible for the elimination of hunting is not completely understood, it is believed that the very slight resistance to the flow of air provided by the porous sleeve tends to cushion or dampen the impact effect of compressed air upon the forward surface of the primary valve member from the moment the seal between that member and the primary valve seat is broken, and this resistance combined with the guiding or stabilizing effect of the sleeve eliminates excessive or erratic axial movement of the primary valve member. The porous construction of the sleeve thereby strains the air to cushion its force and to eliminate the hunting movement which would otherwise occur.

As indicated above, the sleeve also has a "snubbing" or guiding function apart from its damping action. In cooperation with the primary port 24, it defines the path of movement of the primary valve member 34 and thereby eliminates the possibility of substantial lateral or transverse deviation of that member as it moves between open and closed positions. Also, by so guiding the movement of the primary valve member, the sleeve insures proper seating of the valve member against the primary valve seat.

While in the foregoing I have disclosed an embodiment of the present invention in considerable detail for purposes of illustration, it will be understood by those skilled in the art that many of these details may be varied widely without departing from the spirit and scope of the invention.

I claim:

1. A modulating demand valve for regulating the flow of compressed air to a gas mask, comprising a body having a primary flow passage extending therethrough, a primary valve element normally closing said passage and movable into a plurality of open positions, said body having a secondary flow passage extending therethrough, means connected to said valve element and responsive to the flow through said secondary passage for moving said primary valve element into a position sufficiently open to satisfy the air flow demand whenever the flow in said secondary passage falls below a predetermined level, and a porous sleeve provided by said primary valve element and slidable within said primary passage for preventing erratic and excessive movement of said primary valve element in seeking a proper open position to satisfy the air flow demand when the flow in said secondary passage falls below said predetermined level.

2. In a demand valve structure for modulating the flow of air to a gas mask in accordance with the air flow requirements of a gas mask wearer, said demand valve having a flow port and a valve member for closing and opening the same, pressure responsive means capable of responding to pressure changes in said structure when air is demanded by a gas mask wearer and being opera-

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tively associated with said valve member for moving said member into a sufficiently open position to satisfy the air flow demand, and a porous sleeve provided by said valve member and slidably disposed within said port for preventing erratic and excessive movement of said valve member in reaching a proper open position in response to air pressure acting upon said means when air is demanded by a wearer.

3. The structure of claim 2 in which said porous sleeve is substantially greater in length than the distance of maximum movement of said valve member between open and closed positions.

4. In a demand valve structure for modulating the flow of air to a gas mask in accordance with the air flow requirements of a gas mask wearer, said demand valve having a flow port and a valve member for closing and opening the same, pressure responsive means capable of responding to pressure changes in said structure when air is demanded by a gas mask wearer and being operatively associated with said valve member for moving said member into a sufficiently open position to satisfy the air flow demand, and a porous cylindrical member secured to said valve member and slidably disposed with

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respect to said port for preventing erratic and excessive movement of said valve member in reaching a proper open position in response to air pressure acting upon said means when air is demanded by a wearer.

5. The structure of claim 4 in which said porous cylindrical member comprises a cylindrical wire mesh screen secured at one end to said valve member.

6. The structure of claim 4 in which said porous cylindrical member is substantially greater in length than the distance of maximum movement of said valve member between said closed and open positions.

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